Notice of Allowability	Application No.	Applicant(s)
	09/873,988	YANG ET AL.
	Examiner	Art Unit
	Kandasamy Thangavelu	2123

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *July 28, 2005*.
2. ☒ The allowed claim(s) is/are *3-8,10-12,14-17,19-22,24-26,28-31 and 33-48*.
3. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   a) ☐ All b) ☐ Some* c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.
5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.

   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached

   1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.

   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☒ Information Disclosure Statements (PTO-1449 or PTO/SB/08), Paper No./Mail Date 1/27/2005
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application (PTO-152)
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☒ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☒ Other *Clean copy of allowed claims*.

DETAILED ACTION

Introduction

1. This communication is in response to the Applicants' communication dated July 28, 2005. Claims 4, 5, 15, 29, 33, 37-42 and 47 were amended. Claims 3-8, 10-12, 14-17, 19-22, 24-26, 28-31 and 33-48 of the application are pending.

Examiner's Amendment

2. Authorization for this examiner's amendment was given in a telephone conversation by Mr. John carpenter on September 23, 2005.

An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to the applicants, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

3. In the claims:

Replace Claim 4 with:

4. A computer implemented method of simulating a circuit, the method comprising:

defining a set of differential-algebraic equations of the circuit;

defining a simulation time interval corresponding to the differential algebraic equations;

dividing the simulation time interval into time intervals, wherein the time intervals have corresponding polynomials for each time interval, wherein each polynomial is a portion of an approximation to a desired solution of the differential-algebraic equations; and

applying a collocation method to discretize the differential-algebraic equations;

wherein:

the simulation time interval has M collocation points, and wherein M represents a highest degree of interpolating polynomials;

determining a smoothness for each interval, increasing an order of a solution for an interval if it is smooth, and splitting the interval into at least two sub-intervals if the interval is not smooth;

solving the differential-algebraic equations in each of the intervals wherein approximation to the desired solution of the differential-algebraic equations is

$I_M\, u(t) = \Sigma_{k=0}{}^{M}\, u_k^{\sim}\, T_k\,(t)$,

wherein

I_M represents an M-point interpolation operator,

u(t) represents a solution,

$u_k^{\sim}$ represents Fourier coefficients, and

T_k (t) represents the interpolating polynomial.

Replace Claim 5 with:

5. A computer implemented method of simulating a circuit, the method comprising:

defining a set of differential-algebraic equations of the circuit;

defining a simulation time interval corresponding to the differential algebraic equations;

dividing the simulation time interval into time intervals, wherein the time intervals have corresponding polynomials for each time interval, wherein each polynomial is a portion of an approximation to a desired solution of the differential-algebraic equations; and

applying a collocation method to discretize the differential-algebraic equations;

wherein:

the simulation time interval has M collocation points, and M represents a highest degree of interpolating polynomials;

determining a smoothness for each interval, increasing an order of a solution for an interval if it is smooth, and splitting the interval into at least two sub-intervals if the interval is not smooth;

solving the differential-algebraic equations in each of the intervals wherein approximation to the desired solution of the differential-algebraic equations is

$I_M\, u(t) = \Sigma_{k=0}{}^{M}\, u_k^{\sim}\, T_k\, (t)$,

wherein

I_M represents an M-point interpolation operator,

u(t) represents a solution,

$u_k^{\sim}$ represents Fourier coefficients,

T_k (t) represents the interpolating polynomial; and

a derivative of the approximation is $(I_M\, u)'\, (t) = \Sigma_{k=0}{}^{M}\, u_k^{\sim'}\, T_k\, (t)$,

wherein $u_k^{\sim'}$ represents the Fourier coefficients' derivative.

In Claim 8, Lines 1-2, “the step of applying a collocation method”

has been changed to

-- the step of applying the collocation method --.

In Claim 12, Lines 1-2, “the step of applying a collocation method”

has been changed to

-- the step of applying the collocation method --.

Replace Claim 19 with:

19. A computer implemented method of solving a set of differential-algebraic equations arising in a circuit simulation, the method comprising:

applying a collocation method to each differential-algebraic equation to discretize the set of differential-algebraic equations;

forming a solution to the set of differential-algebraic equations based on the discretized differential-algebraic equations; and

determining an order of accuracy desired in intervals of the differential-algebraic equations to be solved in the simulation;

wherein:

the set of differential-algebraic equations comprises a set of boundary-value differential-algebraic equations, and wherein the boundary-value differential-algebraic equations are discretized in the intervals, and wherein neighboring intervals share a boundary; and

the solution in a particular interval is smooth, and wherein the step of determining the order of accuracy desired in each interval comprises determining whether to increase the order of accuracy of the particular interval.

Replace Claim 20 with:

20. A computer implemented method of solving a set of differential-algebraic equations arising in a circuit simulation, the method comprising:

applying a collocation method to each differential-algebraic equation to discretize the set of differential-algebraic equations;

forming a solution to the set of differential-algebraic equations based on the discretized differential-algebraic equations; and

determining an order of accuracy desired in intervals of the differential-algebraic equations to be solved in the simulation;

wherein:

the set of differential-algebraic equations comprises a set of boundary-value differential-algebraic equations, and wherein the boundary-value differential-algebraic equations are discretized in the intervals, and wherein neighboring intervals share a boundary; and

the solution in a particular interval is not smooth, and wherein the step of determining the order of accuracy desired in each interval comprises splitting the particular interval into at least two subintervals.

In Claim 26, Lines 2-3, "causes the processor to carry out"

has been changed to

-- causes the processors to carry out --.

In Claim 28, Line 2, "cause the processor to carry out"

has been changed to

-- cause the processors to carry out --.

In Claim 30, Line 2, "cause the processor to carry out"

has been changed to

-- cause the processors to carry out --.

In Claim 31, Line 2, "cause the processor to carry out"

has been changed to

-- cause the processors to carry out --.

Replace Claim 33 with:

33. A computer-readable medium carrying one or more sequences of one or more instructions for solving a set of differential-algebraic equations arising in a circuit simulation, the one or more sequences of one or more instructions including instructions which, when executed by one or more processors, cause the one or more processors to perform the steps of:

applying a collocation method to each differential-algebraic equation to discretize the set of differential-algebraic equations;

forming a solution to the set of differential-algebraic equations based on the discretized differential-algebraic equations; and

determining an order of accuracy desired in intervals of the differential algebraic equations to be solved in the simulation;

wherein:

the set of differential-algebraic equations comprises a set of boundary value differential-algebraic equations, and wherein the boundary-value differential-algebraic equations are discretized in the intervals, and wherein neighboring intervals share a boundary; and

the solution in a particular interval is smooth, and wherein the step of determining the order of accuracy desired in each interval further causes the processor to carry out the step of determining whether to increase the order of accuracy of the particular interval.

Replace Claim 34 with:

34. A computer-readable medium carrying one or more sequences of one or more instructions for solving a set of differential-algebraic equations arising in a circuit simulation, the one or more sequences of one or more instructions including instructions which, when executed by one or more processors, cause the one or more processors to perform the steps of:

applying a collocation method to each differential-algebraic equation to discretize the set of differential-algebraic equations;

forming a solution to the set of differential-algebraic equations based on the discretized differential-algebraic equations; and

determining an order of accuracy desired in intervals of the differential algebraic equations to be solved in the simulation;

wherein:

the set of differential-algebraic equations comprises a set of boundary value differential-algebraic equations, and wherein the boundary-value differential-algebraic equations are discretized in the intervals, and wherein neighboring intervals share a boundary; and

the solution in a particular interval is not smooth, and wherein the step of determining the order of accuracy desired in each interval further causes the processors to carry out the step of splitting the particular interval into at least two subintervals.

In Claim 35, Line 2, "cause the processor to carry out"

has been changed to

-- cause the processors to carry out --.

Replace Claim 37 with:

37. A computer implemented method of simulating an RF circuit, comprising the steps of:

determining a plurality of differential-algebraic equations describing operation of the RF circuit;

determining a set of Chebyshev Gauss-Lobatto collocation points for the plurality of differential-algebraic equations, producing a set of intervals;

discretizing each of the differential-algebraic equations based on the Chebyshev Gauss-Lobatto collocation point intervals;

determining a smoothness for each interval, increasing an order of a solution for an interval if it is smooth, and splitting the interval into at least two sub-intervals if the interval is not smooth;

solving the differential-algebraic equations in each of the intervals; and

simulating the RF circuit based on the solved intervals.

Replace Claim 38 with:

38. A computer implemented method of simulating an RF circuit, comprising the steps of:

determining a plurality of differential-algebraic equations describing operation of the RF circuit;

determining a set of Chebyshev Gauss-Lobatto collocation points for the plurality of differential-algebraic equations, producing a set of intervals;

discretizing each of the differential-algebraic equations based on the Chebyshev Gauss-Lobatto collocation point intervals;

solving the differential-algebraic equations in each of the intervals; and

simulating the RF circuit based on the solved intervals;

wherein the step of solving comprises applying a set of at least one high order solution to at least one of the intervals and applying at least one solution from a set of low order solutions to a plurality of the intervals.

In Claim 40, Lines 3-5, "dividing the intervals into smooth and non-smooth categories, applying higher order solutions to the smooth category intervals, and applying lower order solutions to the non-smooth category intervals"

has been changed to

-- dividing the intervals into smooth and non-smooth intervals, applying higher order solutions to the smooth intervals, and applying lower order solutions to the non-smooth intervals --.

Replace Claim 41 with:

41. A computer implemented method of simulating an RF circuit, comprising the steps of:

determining a plurality of differential-algebraic equations describing operation of the RF circuit;

determining a set of Chebyshev Gauss-Lobatto collocation points for the plurality of differential-algebraic equations, producing a set of intervals;

discretizing each of the differential-algebraic equations based on the Chebyshev Gauss-Lobatto collocation point intervals;

solving the differential-algebraic equations in each of the intervals; and

simulating the RF circuit based on the solved intervals;

wherein the Chebyshev Gauss-Lobatto collocation points produce a small number of intervals in areas in which the differential-algebraic equations exhibit high convergence, and a

large number of intervals in areas where the differential-algebraic equations exhibit low convergence.

Replace Claim 42 with:

42. The method according to Claim 41, wherein the step of solving comprises dividing the intervals into smooth and non-smooth intervals, applying higher order solutions to the smooth intervals, and applying lower order solutions to the non-smooth intervals.

Replace Claim 44 with:

44. A computer implemented method of simulating a circuit, comprising the steps of:

determining a plurality of differential-algebraic equations describing operation of the circuit;

determining a set of collocation points for the plurality of differential-algebraic equations, producing a set of intervals comprising at least one high convergence interval and a plurality of low convergence intervals;

applying a higher order solution in the at least one high convergence interval; applying a lower order solution in the low convergence intervals; and

simulating the circuit response using the higher and lower order solutions.

In Claim 47, Lines 4-5, "enforcing a periodic boundary condition at least one of the first and last interval"

has been changed to

-- enforcing a periodic boundary condition at at least one of the first and last interval --.

Replace Claim 48 with:

48. The method according to Claim 44, wherein more low order solutions are applied to the differential-algebraic equations than high order solutions.

A clean copy of the allowed claims is attached.

Reasons for Allowance

4. Claims 3-8, 10-12, 14-17, 19-22, 24-26, 28-31 and 33-48 of the application are allowed over prior art of record.

5. The following is an Examiner's statement of reasons for the indication of allowable subject matter:

The closest prior art of record shows:

(1) an apparatus and method for reduced order modeling of time varying systems and a simulation system for the same; there is interference between the system time variations and the input time variations; the time scales are kept separate using multiple time variables and multiple partial differential equations; providing algorithms for generating reduced order models of any desired accuracy; the method is applicable to RF circuits and for handling non-linearities and oscillations; the non-linear system is modeled using a set of differential-algebraic equations; the

equations are discretized using collocations; periodic boundary conditions are applied for solving the equations (**Roychowdhury,** U.S. Patent 6,687,658);

(2) a procedure for numerical solution of the boundary value problems in differential-algebraic equations; the algebraic equations are non-linear; the time domain is divided into subintervals; the differential-algebraic equations are required to be continuous from one interval to the next interval and are required to satisfy the boundary conditions; this leads to a set of shooting equations; efficient techniques for solving the shooting equations are presented (**Fabien,** "Indirect numerical solution of constrained optimal control problems with parameters", IEEE 1995); and

(3) a method of approximating a differential-algebraic optimization problem by a non-linear program and solving it; the approximation error is minimized by adjusting the collocation points; the predicted cost is minimized by using a multi-criteria optimization method; if the discretization is fine enough and if the collocation points are properly spaced, the approximation error is quite low; a two step procedure involving parameterization and discretization is used to convert the optimization problem with differential-algebraic constraints to an NLP with only algebraic constraints; in the parameterization stage, x(t) and u(t) are approximated by polynomials and piece-wise polynomials; in discretization, the residuals are forced to zero at certain points called collocation points (**Srinivasan et al.,** "A multi-criteria approach to dynamic optimization", IEEE, 1995).

None of these references taken either alone or in combination with the prior art of record discloses a computer implemented method of simulating a circuit, specifically including:

"determining a smoothness for each interval, increasing an order of a solution for an interval if it is smooth, and splitting the interval into at least two sub-intervals if the interval is not smooth".

None of these references taken either alone or in combination with the prior art of record discloses a computer implemented method and computer-readable medium carrying sequences of instructions for solving a set of differential-algebraic equations arising in a circuit simulation, specifically including:

"the solution in a particular interval is smooth, and wherein the step of determining the order of accuracy desired in each interval comprises determining whether to increase the order of accuracy of the particular interval".

None of these references taken either alone or in combination with the prior art of record discloses a computer implemented method and computer-readable medium carrying sequences of instructions for solving a set of differential-algebraic equations arising in a circuit simulation, specifically including:

"the solution in a particular interval is not smooth, and wherein the step of determining the order of accuracy desired in each interval comprises splitting the particular interval into at least two subintervals".

None of these references taken either alone or in combination with the prior art of record discloses a computer implemented method of simulating an RF circuit, specifically including:

determining a set of Chebyshev Gauss-Lobatto collocation points for the plurality of differential-algebraic equations, producing a set of intervals;

discretizing each of the differential-algebraic equations based on the Chebyshev Gauss-Lobatto collocation point intervals;

determining a smoothness for each interval, increasing an order of a solution for an interval if it is smooth, and splitting the interval into at least two sub-intervals if the interval is not smooth.

None of these references taken either alone or in combination with the prior art of record discloses a computer implemented method of simulating an RF circuit, specifically including:

determining a set of Chebyshev Gauss-Lobatto collocation points for the plurality of differential-algebraic equations, producing a set of intervals;

discretizing each of the differential-algebraic equations based on the Chebyshev Gauss-Lobatto collocation point intervals;

solving the differential-algebraic equations in each of the intervals; and

simulating the RF circuit based on the solved intervals;

wherein the step of solving comprises applying a set of at least one high order solution to at least one of the intervals and applying at least one solution from a set of low order solutions to a plurality of the intervals.

None of these references taken either alone or in combination with the prior art of record discloses a computer implemented method of simulating an RF circuit, specifically including:

determining a set of Chebyshev Gauss-Lobatto collocation points for the plurality of differential-algebraic equations, producing a set of intervals;

discretizing each of the differential-algebraic equations based on the Chebyshev Gauss-Lobatto collocation point intervals;

solving the differential-algebraic equations in each of the intervals; and

simulating the RF circuit based on the solved intervals;

wherein the Chebyshev Gauss-Lobatto collocation points produce a small number of intervals in areas in which the differential equations exhibit high convergence, and a large number of intervals in areas where the differential equations exhibit low convergence.

None of these references taken either alone or in combination with the prior art of record discloses a computer implemented method of simulating a circuit, specifically including:

determining a set of collocation points for the plurality of differential-algebraic equations, producing a set of intervals comprising at least one high convergence interval and a plurality of low convergence intervals;

applying a higher order solution in the at least one high convergence interval; applying a lower order solution in the low convergence intervals; and

simulating the circuit response using the higher and lower order solutions.

6. Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue

fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

7. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Dr. Kandasamy Thangavelu whose telephone number is 571-272-3717. The examiner can normally be reached on Monday through Friday from 8:00 AM to 5:30 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Leo Picard, can be reached on 571-272-3749. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to TC 2100 Group receptionist: 571-272-2100.

K. Thangavelu
Art Unit 2123
September 23, 2005

Paul L. Rodriguez 9/28/05
Primary Examiner
Art Unit 2125